Methodological guide to carrying out planning processes successfully, using geoinformatics and prospective tools

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Keywords: urban planning, prospective, geographical information system.

SUMMARY

The challenge addressed by this research is the development of a methodology that covers the empty space in the traditional view of urban planning to solve territorial problems.
It is a methodological proposal for urban planning processes based on the combination of prospective studies and geospatial analysis. It allows to carry out successful urban planning, to create future georeferenced scenarios as a support for decision making, and to propose a systematic approach to the territory, which will result in the development of effective land policies.

In order to validate this methodology, a comparison was made between the traditional prospective process and the territorial model obtained by the application of this proposal. Additionally, an application on an open-source geographic information system (GIS) such as a plugin in gvSIG, was developed to validate the application of this method to a real case.

Finally, the result of this research, a methodological guide, provides elements for the use of geospatial and prospective tools to support urban planning. It also considers the weak points existing in the traditional process and supports the use of a methodological approach in order to solve the problems inherent in territorial assessments. The research provides elements for the use of geospatial and prospective tools to support urban planning process.

As it was not possible to present the full research in this article, due to limited extension, only the proposal methodology is included. This proposal was validated by a detailed theorical frame of reference in fields as urban planning procedures, requirements to construct successful plans, geographical techniques and prospective tools. Complementary, the comparative study of the state of the art on the subject, at world level, supports the relevance and novelty of the proposal presented in this article. Finally, I present in this article the final product of a long research with the objective of sharing the procedure with others and with the purpose of giving a helpful guide to improve the way that urban planning is made in many countries.

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1. INTRODUCTION

The territory has, intrinsically, a great complexity, due to the coexistence of various contexts, such as social, cultural, environmental and economic issues. Because of this, the construction and implementation of urban planning processes do not respond to rigid linear prescriptions (Vitale, Pascale Medina, Barrientos and Papagno, 2016).

In many countries the focus of urban plans is on the creation of final results after the whole plan took place, but many authors consider that the success of those plans consist of the kindness of the process. The reference to effective land-use plans considers the contemporary vision of land-use planning, which includes not only the elaboration of land-use management plans appropriate to the real problems, but also an integrated and methodical planning process (Volkery, A. and Ribeiro, T., 2009).

The planning process is conceived from an integrative, flexible and participatory perspective; in each of its phases (diagnosis, elaboration, implementation, monitoring and review) there is a permanent view of the present and the future (Rocha, 2017). Planning takes place in the present, but it is the future that is engaged (Hopkins and Zapata, 2007).

On the other hand, since the late twentieth century, various entities, companies and institutions have begun to recognize the need of good quality geographic data as essential inputs for urban decision-making (Fédération Internationale des Géomètres, 2009). However, despite the rapid expansion of geographic information, it should be noted that although geospatial information is considered in the territorial diagnosis, their use is restricted to the initial stage and does not extend to the entire planning process. In addition to this lack, there is a gap in the effective use of spatial analysis tools of geographic data, which are weakly used in land-use planning not only due to the absence of expertise of technical specialists in this field, but also due to the poor existence of useful, reliable and updated geographic information (United Nations Geospatial Information Management Group, 2018).

Therefore, in this research, a methodology is proposed as a reference guide to orient future planning processes. In this methodology, a systemic approach of the territory is presented in which the future dimension takes a preponderant role, through territorial foresight.

To construct this methodology, many aspects were taken into account, such as the recommendations made by many authors related to the criteria of success of urban planning processes (Casanova, 2019). Furthermore, the combined use of different prospective and geomatic tools is incorporated in the guide, in the understanding that they will enrich the planning process to be carried out.

2. PROPOSED METHODOLOGY

Initially, it is vital to define the stages to carry out an urban planning process. Although there are different descriptions of the planning process according to the literature linked to land planning, they are all similar and cover the main stages, included in this guide: the formulation stage (preparatory, analysis and diagnostic and the proposal phase), the processing stage and the management stage (including the monitoring and evaluation of the resulting plan). (Metz, 2011) (Goodspeed, 2017).

The proposed methodology consists of different tasks to be carried out in each stage of the planning process represented in the following diagram:

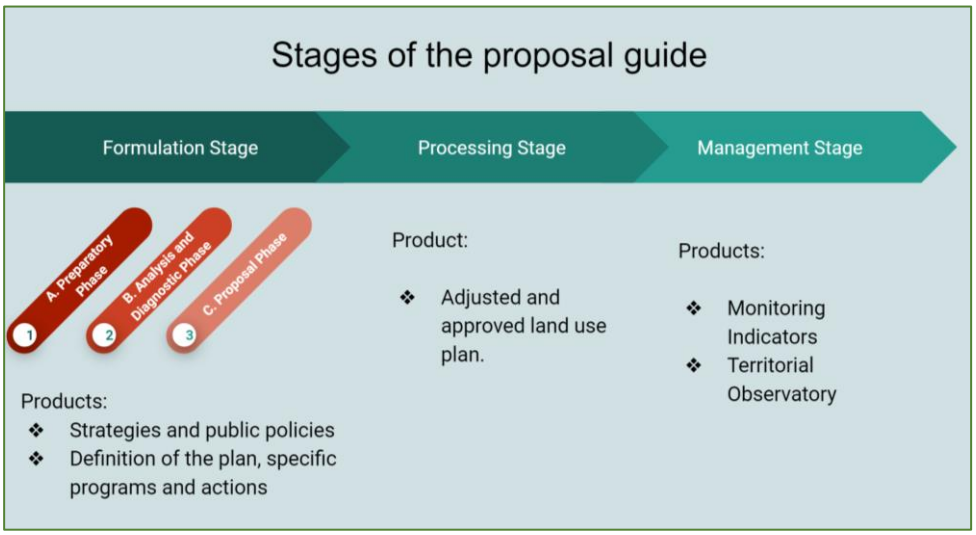

Fig. 1: Stages of the proposal methodology.

2.1 Formulation stage

A. Preparatory Phase

This phase involves fundamental aspects that are included in numerals A.1 and A.2:

- Integration of a planning team supported by the government authorities, which validates and provides the necessary resources to carry out the process of urban planning.
- Definition of the object of the planning process with a territorial, thematic and spatial delimitation, as well as the objectives to be achieved after the plan is completed.
- Creation of media plataforms for community participation.

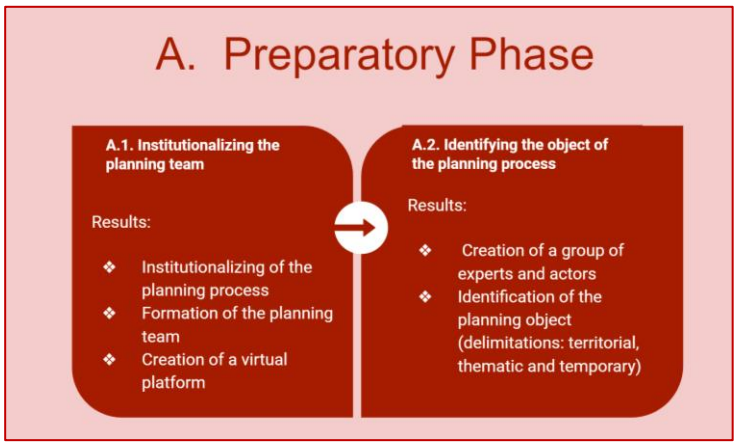

Fig. 2: Results of the Preparatory Phase.

A.1. Institutionalizing the planning team

Political and institutional support from the authorities is essential for the success of a planning process. It is especially important that the government considers that it is valid, relevant and necessary to carry out the process of territorial planning with a prospective vision. (Vitale, et al., 2016).
In this sense, government and society must become aware of the consequences and high costs, not only economic, of carrying out a bad or weak urban planning process (Metz, 2011). The dissemination of good practices, as well as informing governments and training technicians and society about the application of foresight tools, is a key element for the real incorporation of prospective into territorial planning processes.

As the first element of this methodology, the emphasis is placed on the need to create a governmental institutional unit. Whether the unit is national or provincial it should coordinate all public land planning in its region, integrated by transdisciplinary teams (Massiris Cabeza, 2002). In the case of several countries that have a consolidated spatial data infrastructure institution, this could be an appropriate place to integrate the land prospective component and institutionalize the planning processes.
The technical planning team should be inter-institutional and transdisciplinary, and include personnel trained in areas such as foresight, prospective, urban planning, geomatics, information technology and communications (Vitale, et al., 2016).

The team will carry out:

— The coordination and guidance of the entire process of territorial planning.
— Connect with government officials, experts, and civil society.
— Coordinate with national or regional geospatial data and statistics institutions to promote the integration of land administration systems, including geospatial data and indicators required for monitoring.
— The preparation of basic information and knowledge that will support the discussions and elaboration of plans. The processing of geospatial data, not only as a visualizer of results, but also as creators of prospective scenarios.

- The proposal of adjustment of the prospective tools that will be used during the planning process.
- The identification of the primary actors and experts for each thematic approach. The systematization of the collective construction that is created among the diverse actors in each stage of the process.
- The communication to the community, in an adequate, understandable, and inclusive way, of the information related to all the land planning processes.
- The design and maintenance of a virtual platform that allows the visualization, analysis and simulation of results and consequences of the implementation of certain plans or territorial actions, as well as the entry of collaborative data provided by the community.
- The implementation and maintenance of a virtual platform that makes citizen participation and monitoring viable. And a platform that promotes the creation of a community involved in all stages of the planning process. Forum that will allow the exchange of ideas, proposals, suggestions, reports, and complaints.
- Monitor and follow-up of the process and periodic revisions of the plans and the results of the process.
- The development and maintenance of a repository of good local and global practices related to land and prospective processes.

A.2. Identify the object of the planning process

The processes of urban planning are carried out to solve problems or territorial situations, as well as to plan or organize a certain region. For this purpose, it is necessary to recognize, know and delimit the object of the planning process on which the focus will be placed on. (Metz, 2011).
In this sense, three delimitations are proposed (Vitale, et al., 2016):

- Land, to define the geographical area in which the planning interest is presented.
- Thematic, to clearly identify which is the topic or topics under study related to the problem or situation.
- Temporary, to define a horizon year that will allow the visualization to be cut out for the future and will serve as a guide for the prospective process.

To carry out these tasks, various prospective tools can be used, such as relevance trees and panel of experts, which will allow the definition of the problem under study, the thematic axes that should be addressed, as well as the key actors that should participate in the process.

Steps suggested in this phase:
1. The team will make an initial proposal of the object of the planning process, with a primary outline of the territorial space involved, and the objectives to be achieved by the plan to be elaborated. The main thematic axes related to the problem or situation under study should be defined.
For this purpose, the technique of relevant trees will be used, which allow the division of the land system and object of the planning into thematic areas, which facilitates the identification of experts and actors who will be key components and participants in the process. (Salas, 2013).

2. The primary outline of the delimitation of the object of study will be submitted for review through the collection of opinions both from civil society (to be published in the virtual platform created in the initial phase) and from the group of experts defined in the previous step. For this purpose, the expert panel tool will be used, which allows the collection of experts' opinions and discussions in order to analyze and elaborate joint visions, as well as to identify other relevant actors or experts to be included. This process will allow discussing hypotheses and building joint visions of the future (Godet and Durance, 2009).
Although in this phase there is a predominant role of experts or direct actors related to the planning object, it is suggested to collectivize the process. It is recommended that as different instances that are carried out, its proposals and primary results, are published in the virtual platform. It is also important that it receives the opinions and contributions from the civil society.

B. Analysis and diagnostic phase

The territorial diagnosis consists of the collection, systematization, and analysis of the data of the region under study. (Vitale, et al., 2016). As the land system has a huge complexity, models are used to represent and simplify such reality. Models make possible the comprehension of the system (Xiang & Clarke, 2003). The accuracy, relevance and pertinence of the data included, as well as the correct identification of the key dimensions that will represent the territory are fundamental components to ensure the quality of the results of the planning process (Vitale, et al., 2016).
The diagnosis, then, consists of the interpretation and assessment of the current territorial model, considering its historical trajectory and the elaboration of possible (future) scenarios based on the analysis of its evolution (Godet, et al., 2009). One of the scenarios elaborated is the called desirable scenario. This one is the one which is desired to take place in the future. Scenario that will guide the definition of the plans and actions that will be included in the proposal phase (Vitale, et al., 2016).

The analysis and diagnostic phase will be carried out in three sub-stages:

- Creation of the current territorial model.
- Creation of the future territorial model.
- Definition of the vision of the future.

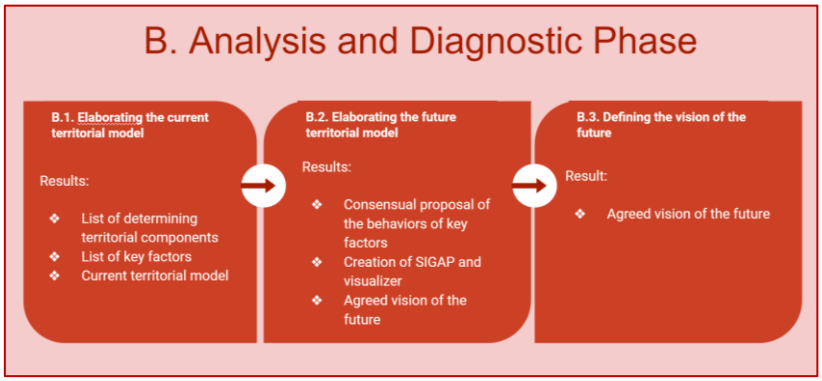

Fig. 3: Activities and Results of the Analysis and Diagnostic Phase

B.1. Creation of the current territorial model

The starting point for the elaboration of prospective scenarios is to recognize the key components that are the driving forces of the land transformations related to the object of study, as well as to anticipate the future reactions of the different agents. Therefore, it is necessary to identify the agents involved in the variation of their behavior in time and space (Salas, 2013). The identification of the key components and their relationships will shape the current territorial model.

Steps suggested in this phase:
1. Identification of territorial components
As regions are affected by internal and external elements, it is necessary to identify those components that are relevant in its dynamics. The factors of change are the set of territorial, economic, social, cultural, and political conditions whose behaviors and interrelations are elements that influence territorial transformations (Salas, 2013).
This process is based on a diagnostic synthesis carried out by the planning team, which draws up an exhaustive list of the land components that will be published on the virtual platform (created in the previous phase). This list must be reviewed and refined; for this task experts, who were identified in the previous phase, are consulted. Although these consultations can be carried out by different techniques, the use of the Delphi method is recommended.

2. Identification of key factors
After having the list containing the most important land components of the system, it is necessary to select which of them are the key and determining elements of the dynamics of change.
For this selection, the group of experts carries out a structural or multivariate analysis of the system. This implies studying the relations between components and prioritizing those which are critical considering criteria of influence and dependence (Vitale, et al., 2016).
This structural analysis consists in linking the processes of territorial transformation in a double-entry matrix, where the rows and columns correspond to each of the land components. The planning team collects all the matrices made by the experts, elaborates a final matrix and generates a influence-dependence plane. The interpretation of this plane provides a good approximation of the system's behavior and the dynamics of its components. Furthermore, in the influence plane it is possible to identify the subset of components located in the upper right quadrant that are critical in the system and therefore define the current territorial model. Once the key components of the system have been identified, the planning team shares them so that the group of experts and the virtual community can give their opinions to adjust, validate and agree on the current territorial model.

B.2. Creating the future territorial model

The future territorial model is a subset of prospective scenarios that arise from a set of scenarios defined through the analysis of the different possible evolutions of the current territorial model. The evolutions are analyzed considering the robust and emergent tendencies since they are the

ones that have more probability of being concreted in the future. In this way, these are determinant on the behavior of the key factors. (Godet et al., 2009).
Prospective highlights the relevance of including the study of the possible evolution of key factors if some type of rupture or unexpected event occurs, since it will result in unpredictable scenarios. (Nalerio, 2010).
Although there is no single technique for building the future territorial model, they all address, to one degree or another, the following aspects: analysis of the problem; raising key questions (where we came from, where we are, who we were and who we are); identification of trends and uncertainties and construction of various alternatives (Vitale et al., 2016).

Suggested steps in this phase:
1. Trend analysis:
In this stage, the evolution of the current territorial model is analyzed, considering the different possible evolutions for each key factor. While the most clearly identified and visibly accepted evolutions are those that come from the study of historical evidence, such as robust and emerging trends, possible ruptures, and weak signals may alter the most sustained trends over time, and therefore they must also be considered. (Nalerio, 2010).
The planning team collects and integrates historical data that reflects the evolution of each of the key factors and proposes possible mutation coefficients according to the possible behaviors for each trend.
The information is shared with the group of experts and the community, in virtual or face-to-face meetings or workshops, to receive their input.
2. Elaboration and validation of scenarios
The prospective tool for the elaboration of scenarios is the most recommended for creating land diagnoses for a future horizon (Goodspeed, 2017). Another important aspect of this tool is that it builds bridges between prospective modeling communities, land planning, and civil society (Xiang et al., 2003) (Goodspeed, 2017). This generates synergies and a participatory space that enriches the planning process (Hopkins and Zapata, 2007).

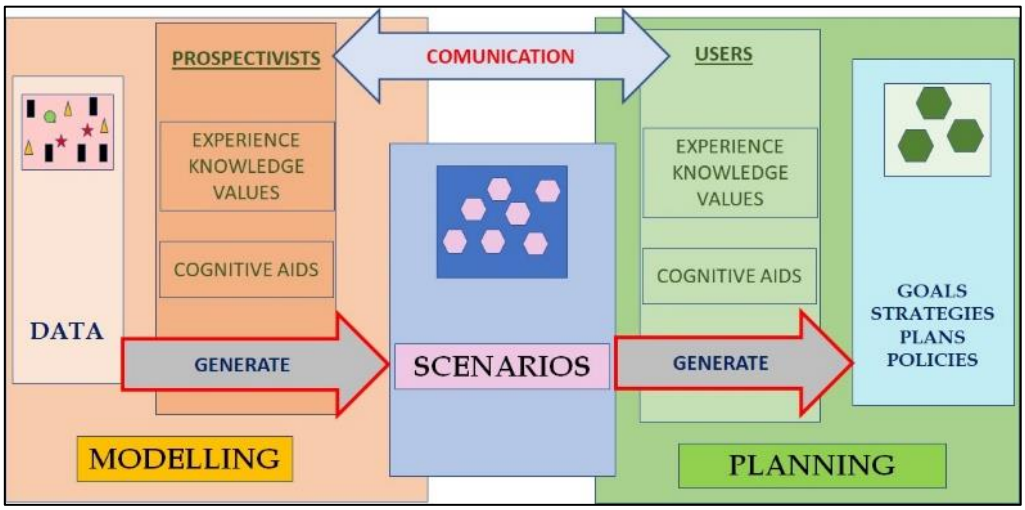

Figure 4: Representation of the duality of functions of the scenarios and interrelation with the communities involved. Source: Adapted from the illustration by Xiang and Clarke (2003).

Therefore, the method proposed includes the elaboration of prospective scenarios.
The elaboration of prospective scenarios can be considered as the simulation in time of the evolution of a model (Destate and Durance 2009). Prospective tools allow the definition of various scenarios that represent the different trends analyzed in the previous stage; some will be validated, and others discarded once the next stage is completed.
Not only the use of the prospective tool of scenarios is included in the methodology, but also geomatic tools are included. These enable the generation of georeferenced scenarios. These tools allow the management of geospatial data that represent the current territorial model and the different evolutionary behaviors agreed upon in the previous stage.

The relevance of using geospatial information as an input for proper decision making has been widely exposed in the document "Some Current Challenges on Geospatial Data" of the group of experts of UN-GGIM (UN-GGIM, 2013). Consequently, the inclusion of a mapping visualizer that represents the scenarios created is proposed in this methodology. This inclusion will promote a first approach for the construction or consolidation of a spatially enabled society in each region. (Williamson, Enermark and Rajabifard, 2010).

The methodology proposes to develop an application to be executed by the planning team, is called Geographic Information System for Prospective Analysis (SIGAP) and enables the elaboration of prospective scenarios based on geospatial information.
One of the objectives of SIGAP is that the prospectivist can benefit from the software's functionalities to systematize and expedite the scenario-building process. (Cristiani & Moreno, 2016). In order to test the proposal of using GIS to build scenarios a plugin in gvSIG was developed. Based on the results of the application of this development to a specific case of study it can be stated that the SIGAP allows the elaboration, validation and grouping of prospective scenarios, thus it enables the generation of the future territorial model. This requires that the planning team enters the current territorial model by loading the data layers that represent each key factor and their mutation coefficients for each behavior considered (thus creating the morphological matrix).
The process of elaborating prospective scenarios in SIGAP starts with the creation of a project in the software GIS and the input of the layers representing each of the key factors considered in the definition of the current territorial model. The diagram below shows the different tasks that make up the processing in SIGAP.

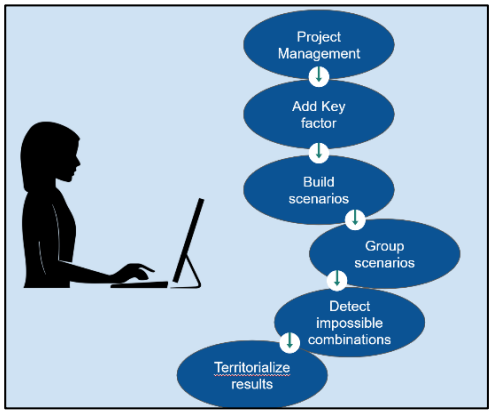

Figure 5: Diagram of the tasks on the SIGAP.

In order to group scenarios four categories are considered:

- Trend: It corresponds to the most probable future and is imposed respecting the historical pattern of each key factor. (Rubio, 2012).
- Contrasted: It is a scenario in which a change in past trends is visualized. A radical change or major break with the trend, results in a different scenario (Cristiani et al., 2016).
- Optimal: It arises from a decision made to achieve a desirable future image. The basic criteria to define it is oriented to improve the quality of life of the population. (Rubio, 2012).
- Inadmissible: These are the opposite scenarios to the desirable future image.

It is suggested that the future territorial model is represented by three territorial scenarios: the trend, the contrasted and the optimal one. The planning team selects these three scenarios and shares them with the virtual community and the group of experts, providing instances of comments in the virtual platform exchange forums.

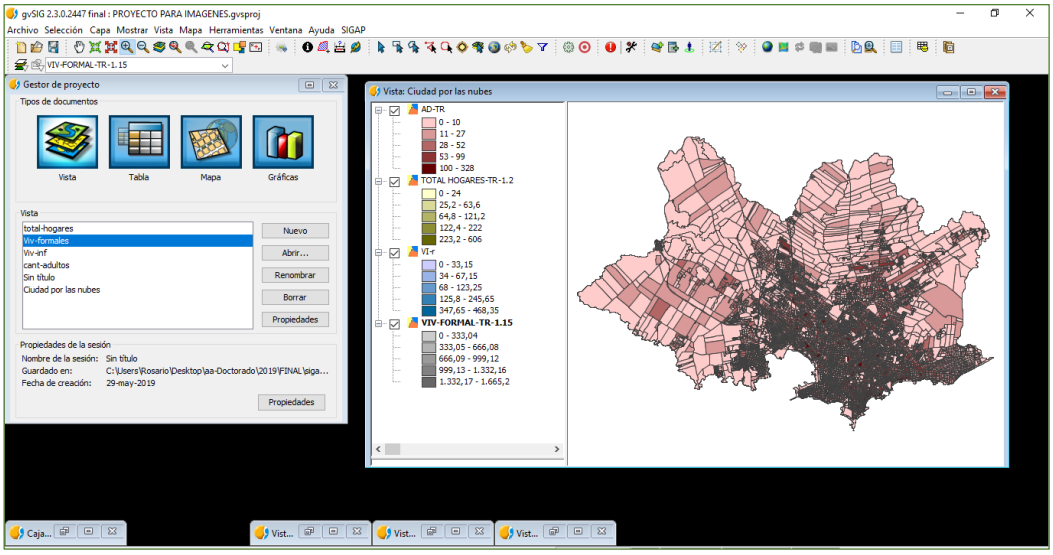

Figure 6: Scenario visualization.

B.3. Vision of the Future

The vision of the future in land planning can be understood as a desirable, achievable situation with the possibility of transforming the territorial reality to meet the initial objectives proposed in the planning process.

Workshops are held with the group of experts and actors involved, where the planning team presents the three scenarios selected in the previous stage.

The planning team makes the presentation on the SIGAP or the web viewer itself, where it socializes the cartography generated for each scenario. The geographic visualization in a GIS allows, besides having a clear geospatial image of each scenario, the development of various spatial analyses among the scenarios and other territorial elements, which can be decisive for the choice of the future vision.

C. Proposal phase

At this stage we move from anticipation of the desired future to action to achieve it. This is the moment when decision makers must define the strategies for land development, in the short, medium, and long term. These strategies translate into a set of actions that make it possible to move from the starting point of the present, from the current territorial model, to a vision of the future.

Figure 7: From the current territorial model to the vision of the future.

At this stage, the aim is to respond, through the creation of strategies, to the different problems and opportunities identified in the initial stage.
The strategic guidelines (land use plan) are the land use policies that are proposed with the aim of transforming the territorial reality and express the political will of those responsible for the government. This stage is mainly carried out by the planning team, the actors involved and the inter-institutional political decision makers who will have an integral vision of the global political situation and will be able to assume real commitments so that the actions are carried out.

2.2 Processing stage

At this stage, the administrative process is carried out to formalize the approval of the plan proposed in the previous phase. Each technical team must become familiar with the local regulations to meet the requirements established for the approval of the plan.
In any case, independently of the requirements established in each local regulation, it is suggested to carry out instances of dissemination of the plan, programs and actions with the community in general. It is recommended that initially the plan proposal is published on the platform, with clear and understandable documentation for the general public, and later on, instances of exchange in discussion forums.

2.3 Management stage

The management stage includes the phases of monitoring, follow-up, and review of the plan.
The whole planning process, although it has an order, is an iterative process that constitutes a cycle that is deepened in the successive revisions.
It is essential to have the current territorial model in order to evaluate the impact of the interventions resulting from the application of the plan, since it defines the baseline that is the starting point of the monitoring process. In addition, it is necessary to establish indicators, referring both to the way the plan is implemented and to its impact with respect to the objectives. These must be measured periodically, not only to evaluate the magnitude of the impacts, but

also, to make the necessary adjustments to the plan in order to adjust the actions to achieve the goals.
In order to carry out the actions planned in this stage; the planning team must set up a virtual territorial observatory. The observatory seeks to monitor the plan, study, and understand the land dynamics in order to influence the processes of territorial transformation. An observatory is an area of participation, integration and management of information and knowledge. Therefore, it is proposed that the observatory be mounted on the visualizer created in the diagnosis stage, so that data management is done in a geospatial way. This allows the virtual community and the spatially enabled society to enter collaborative data that are inputs to monitor the real impacts on the territory.

Currently, there are new tools and forecasting models based on new technologies, focusing on the ways in which these are incorporated into the environment. Although, in recent years there have been important advances in the optimization of hardware and software for the proper handling of big data, they have not managed to provide efficient management when it comes to geospatial big data (Karimi, 2017). This makes it clear that there is a certain complexity when handling geographic data with this tool, so it is suggested that, in the future, automatic learning techniques are incorporated so that enriched scenarios can be constructed due to the great availability of data accessible on the platform.

3. CONCLUSION AND SUGGESTIONS

From the detailed study of the specific literature, it was possible to verify that:

- There are deficiencies in the definition of evaluation methods for territorial planning processes. Systematic studies that analyze the reliability of the plans elaborated have not been carried out.
- Although there is accumulated experience in the application of prospective techniques at the service of strategic plans, their main focus is on the elaboration of scenarios as inputs in the diagnosis stage. The massive use of other techniques has not been incorporated into the other stages of the planning process.
- The incorporation of geomatic tools to the planning process is insufficient. Geospatial data has been incorporated to represent cartography in the preparation stage, but its use is limited to that phase, it does not advance to the following ones and the potentialities offered by the spatial analysis and its incorporation to the monitoring stage of the plan are not considered.
- Good quality territorial planning requires a land administration structure that includes administrative, control and monitoring aspects of its development.

The inclusion of diverse prospective techniques to the different phases of the preparatory stage of the planning process, as well as the existing geomatic tools and the applications developed for the processing of geospatial data in specific projects, are useful to elaborate successful territorial planning processes.

From the point of view of the validation of the methodology, the successful development of a specific application in gvSIG for the elaboration of the prospective scenarios and the possibility

that this offers to carry out spatial analysis with other territorial aspects opens the door to a more robust simulation of the possible consequences and implications of opting for one or another action foreseen in the urban plan.

Each of the components of the methodological proposal, and, therefore, the procedure is reliable and applicable to different land realities and problems.

As part of the development of this research, some future lines of study were identified:

- Application of the methodology proposed in this research to diverse case studies that address different problems on different regions.
- Research on the use of big data as a learning tool for the elaboration of prospective scenarios based on the study of the behavior of each key factor. Currently, the complexity of the management of big data in relation to geography requires deepening academic research.
- Research on the potential use of collaborative data as fundamental inputs to sustain an observatory for monitoring and following up on territorial plans.
- Elaboration of academic proposals to train the community on issues related to territory, particularly on the use, capture, visualization, and interpretation of geospatial data, which will result in more spatially enabled societies.

To conclude this research, some suggestions are included:

- It is necessary to raise awareness among decision makers, government officials, politicians, technicians, and society in general about the advantages of using geospatial data when making land planning. In addition, it is particularly important to have statistical data linked to the territory that should be updated periodically and with appropriate procedures.
- It is necessary to have financial policies that allow the collection of geospatial data in a permanent and sustained way, since these data will be a fundamental input for a territorial monitoring and follow-up observatory.
- It is proposed to work on the training of new generations of professionals linked to land planning, specialized in prospective techniques and geomatic tools. This will result in the use of these tools in a more intuitive manner. Their application will be more reliable since the ignorance of their potential will not be an obstacle.
- It is particularly important to promote the creation and consolidation of a spatially enabled society. It is required that societies know and apply the potentialities of geospatial data for their benefit. In order to fulfill this objective, it is necessary to train the community on the concept of spatiality, so that they can interact and decide on the land aspects that affect them.

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